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NOTE ON THE EFFECT OF CHEMICAL COMBINATION ON THE STRUCTURE OF THE K ABSORPTION LIMIT

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ABSTRACT

The structure of the *K* absorption limits of some chemical compounds was examined with the double x-ray spectrometer. This instrument has been previously described. The *K* absorption limits of the elements Ag, Mo and Cu and the compounds Ag_2S, Ag_2O, also MoO_3, MoS_2 and Mo_2O_3 were examined for increase in width or fine structure. The width for the pure element decreases with increasing atomic number. The general effect of the chemical action was to broaden the absorption limit, but there was little displacement. In one case, M_2O_3, there was evidence of fine structure. The silver salts appeared to be considerably reduced by the x-rays.

Effect of temperature on the K absorption limit.—Recent experiments of H. S. Read (Phys. Rev. **27**, p. 373, April 1926, and **28**, p. 898, Nov. 1926) indicate an increase of absorption due to temperature of the absorbing element. Also the results were interpreted as due to a shift in the absorption limit. This matter was examined with double spectrometer. A strip of Mo was heated to incandescence in vacuum. The position and form of the *K* limit was compared to that for cold strip. They were identical. No effect of temperature was detectable. This method would probably detect one-tenth the displacement estimated by Read.

THIS is a report of some experiments designed to test the possibilities of the double x-ray spectrometer in the investigation of minute effects. The instrument as used for high resolution has been already described and need not be repeated here.[1]

Both structure and shift of position in the *K* absorption limit of elements of small atomic number due to chemical combination have been observed by Bergengren and Lindh.[2] This indicates that chemical action not only involves the valence electrons but extends throughout the atom affecting even the inner energy levels. This effect has not been heretofore observed in the case of elements of higher atomic number such as silver and molybdenum.

The energy of chemical action is very small compared to the energy of the inner levels of atoms of high atomic number. The disturbance of these levels should be small, the readjustment of mutual energies being largely confined to the outer levels of the atoms. The double spectrometer here used gives the width of the absorption limit if correction is made for crystal imperfections.[1] We have investigated a few compounds of silver and molybdenum. This included of course the absorption limits of the elements themselves.

The metal was used in the form of thin sheets rolled to the proper thickness to give a convenient discontinuity at the *K* limit. The first crystal (*A*) was set at proper angle to reflect a wide region each side of the limit. The second crystal was then rocked through a small angle each side of the absorption limit positions. The forms of the discontinuities observed for silver, molybdenum and copper are shown in Fig. 1. These curves are not corrected for crystal imperfection. The break is quite sharp, and the sharpness increases with increasing atomic number. The full width being: for Ag, 0.38 XU; Mo,

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[1] Bergen Davis and Harris Purks, Proc. Nat. Acad. **13**, No. 6 (June 1927) and **14**, No. 2 (Feb. 1928.)

[2] Siegbahn, Spectroscopy of X-rays, p. 142.

0.48 XU; and for Cu, 0.70 XU. We expect in the near future to extend these observations to elements of the highest atomic number.

The absorption limits of the compounds MoO_3, Mo_2O_3 and MoS_2 and also the two compounds of silver Ag_2S and Ag_2O were then investigated. These compounds were all used in the powdered form. A thin film of waterglass was painted on a piece of paper. While still wet, the powder was sprinkled on the water-glass to a thickness that would give a convenient absorption. Water-glass was used as a binder rather than organic compounds containing carbon such as sugars or glues. The carbon of such substances would assist in the reduction of the compounds under the action of x-rays.

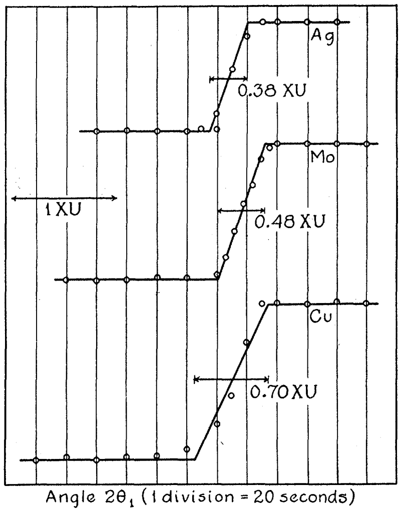

Fig. 1. Forms of the discontinuities for silver, molybdenum and copper.

The curves for the molybdenum compounds are shown in Fig. 2. The limit is much broadened in the case of MoO_3 and MoS_2. The center of gravity of the limit, however, is only slightly displaced.

In the case of Mo_2O_3 there is marked evidence of fine structure. Fine structure may be present to a less degree in the other two compounds. The results obtained for the two compounds of silver are shown in Fig. 3. The absorption limit is broadened by chemical action. The center of gravity is only slightly displaced. The curve for Ag_2O shows a break that may be due to fine structure. The lower part of the curve is nearly the same as that for pure silver, the upper part is shifted toward the long wave-length. The effect may be due to the partial reduction of the silver salt by the x-rays. The lower part which is identical with the curve for pure silver, arises from the part of the salt that has been reduced. It was observed that the silver salt

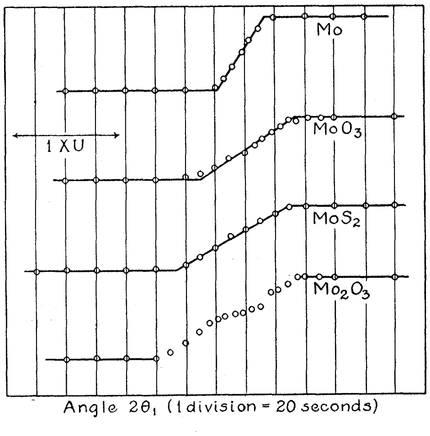

Fig. 2. The discontinuities for molybdenum compounds.

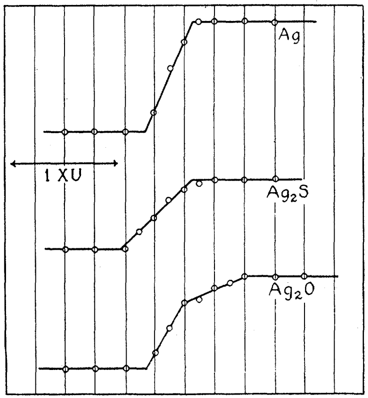

Fig. 3. The discontinuities for silver compounds.

turned dark after a few minutes exposure to the radiation. The molybdenum salts did not appreciably change color under the action of the radiation.

These results indicate that in the case of chemical combination, the readjustment of energy is not confined to the outer layers of the atom, but extends throughout the whole atomic system. These results also suggest that there are possible errors in the wave-length measurements of the several series of some of the elements. Many elements cannot be used directly as a target in an x-ray tube. In these cases stable compounds of the elements have been used. The K limit is affected by the chemical combination and the K emission series is probably similarly affected. The spectral lines would at least be broadened. They should also contain fine structure not present in the radiation from the element. The L and M series would be affected to a still greater extent. This suggests an investigation of the fine structure in the emission series of compounds.

NOTE ON THE EFFECT OF TEMPERATURE ON THE K ABSORPTION LIMIT

H. S. Read[3] has reported an effect of temperature on the absorption of x-rays. An increase of absorption with increase of temperature was found in every case investigated. This effect, if confirmed, is of interest and importance, more especially as it is not anticipated by our theories of emission and absorption of radiation. In the second paper Read reports an investigation of the dependence of the effect on wave-length. The absorbing element of silver was given a temperature range from 20°C to 850°C. The results were interpreted as indicating a shift of the K absorption limit. The shift assigned being 0.2 XU, which is equivalent to 11 volts.

We have investigated this temperature effect in molybdenum using the double x-ray spectrometer. A strip of this metal about 6 mm wide and of proper thickness to give a convenient break at the absorption limit was mounted in a Pyrex tube with thin windows. The strip was attached to large tungsten lead-in wires and could be heated to any desired temperature by an electric current. The tube was exhausted and mounted between the two slits of the spectrometer in such way that the beam of x-rays would pass through the strip of molybdenum.

The K discontinuity with cold strip was identical with that shown in Figs. 1 and 2. The Mo strip was then heated to incandescence and the absorption break again measured. No effect whatever was observed. Within the errors of experiment the readings were the same as those with a cold absorber. We certainly could have observed a shift of three seconds of arc on the second crystal. A shift of 0.05 XU could have been observed. This is equivalent to 1.3 volts. The temperature of the strip of molybdenum was much higher than that of the silver used by Read. The temperature, however was not measured as the strip evaporated through at one point just at the close of the experiment. Since the results were negative it was not considered worth while to re-perform the experiment and measure the temperature with an optical pyrometer.

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[3] H. S. Read, Phys. Rev. **27**, 373 (1926) and **28**, 898 (1926).